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(54) **A method of, and an apparatus for, the protection of an electronic device against destruction by strong electro-magnetic pulses**

(57) In order to protect an electronic device against destruction by strong electromagnetic pulses, the interference energy is divided in terms of frequency, partly reflected and the part which lies in the working range of the device to be protected is delayed and restricted. A frequency-selective delay member (V) is positioned between a coarse protection means (2) and a fine protection means (3).

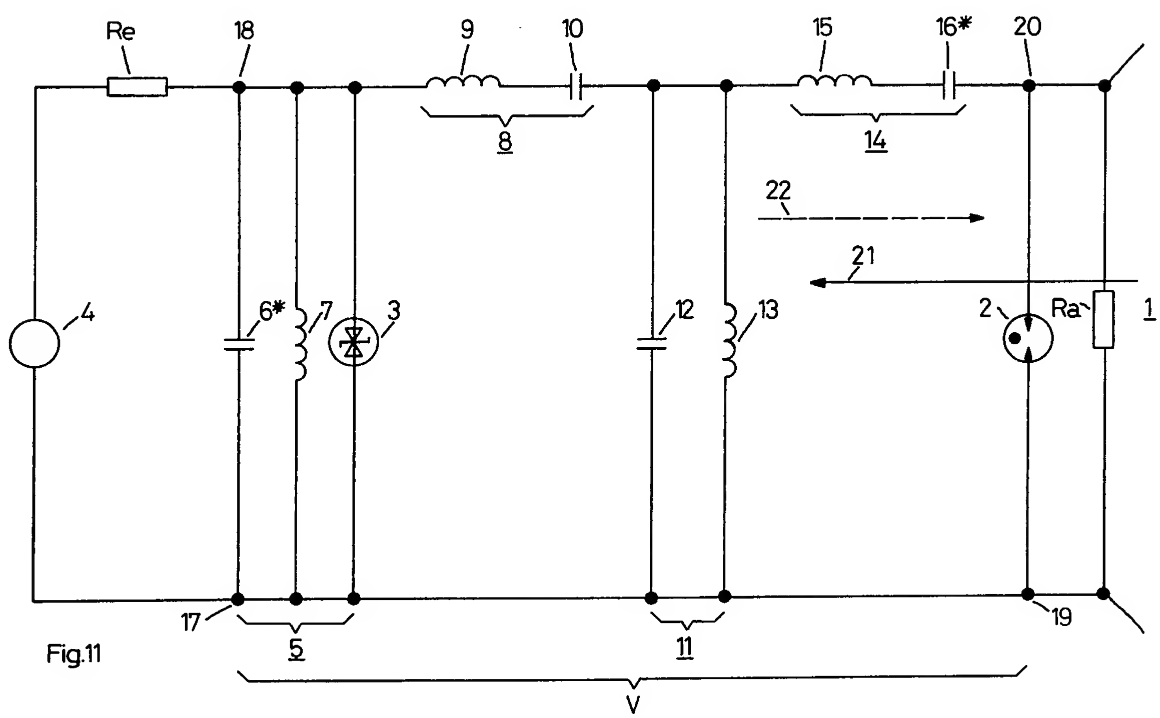

Fig.11

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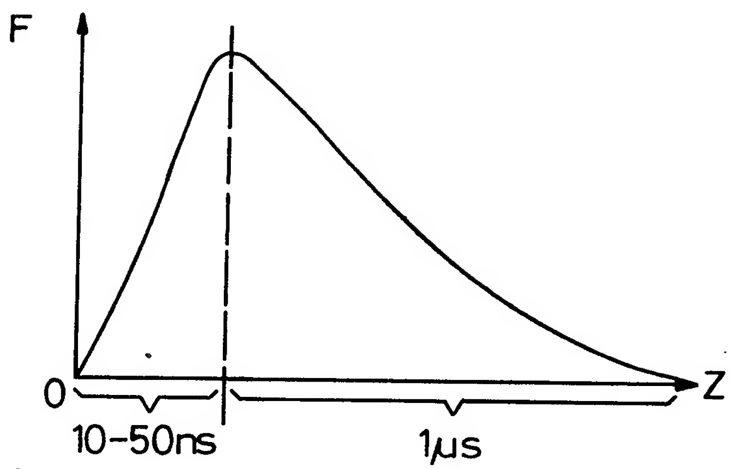

Fig.1

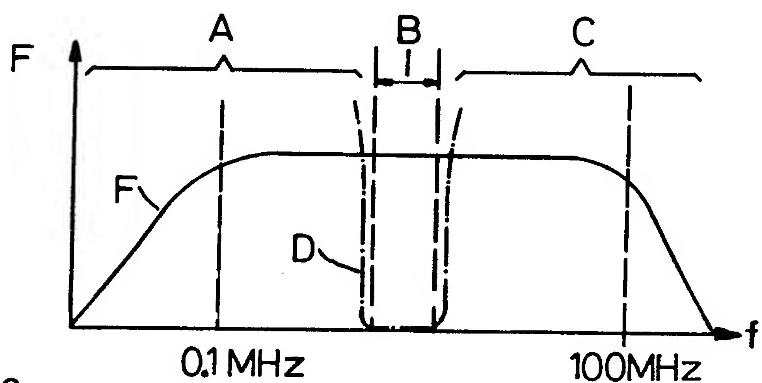

Fig.2

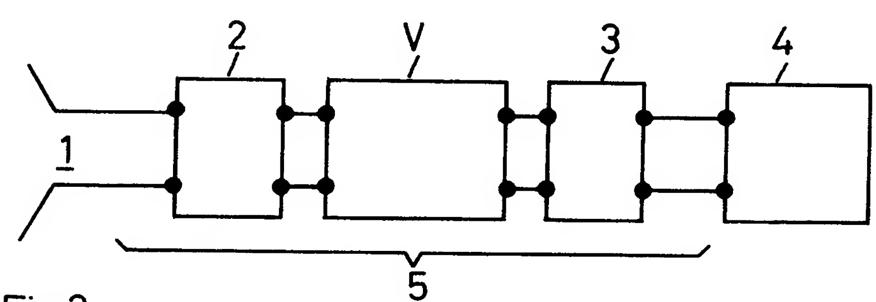

Fig.3

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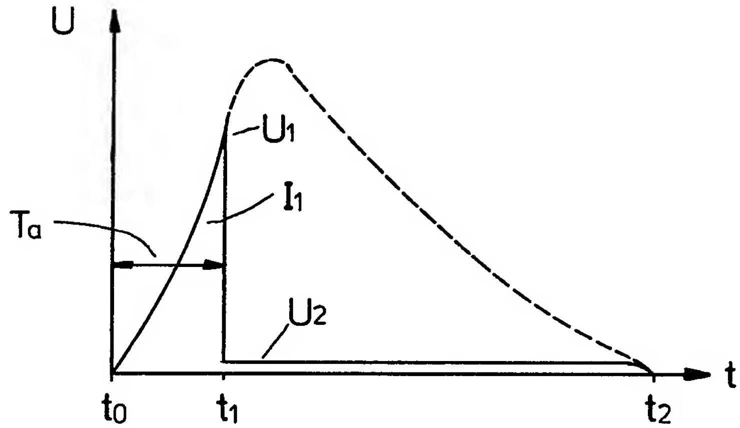

Fig. 4

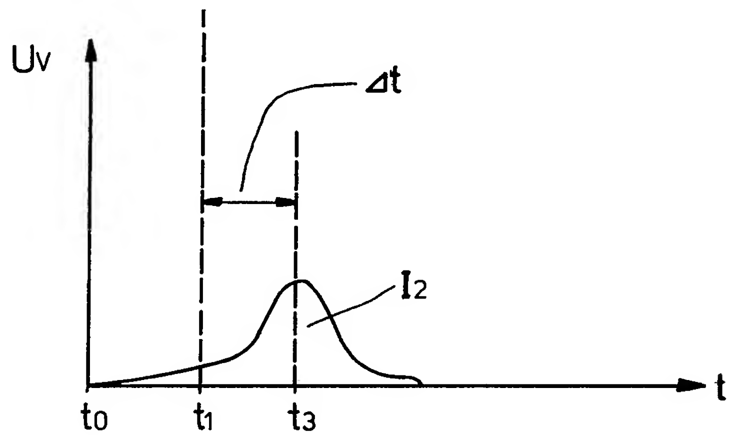

Fig. 5

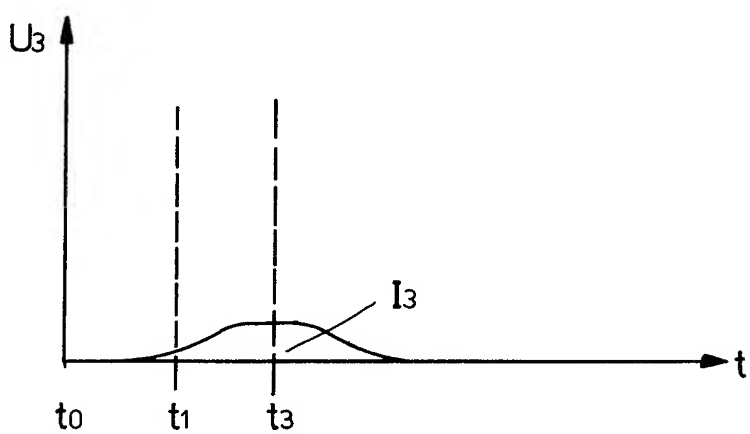

Fig. 6

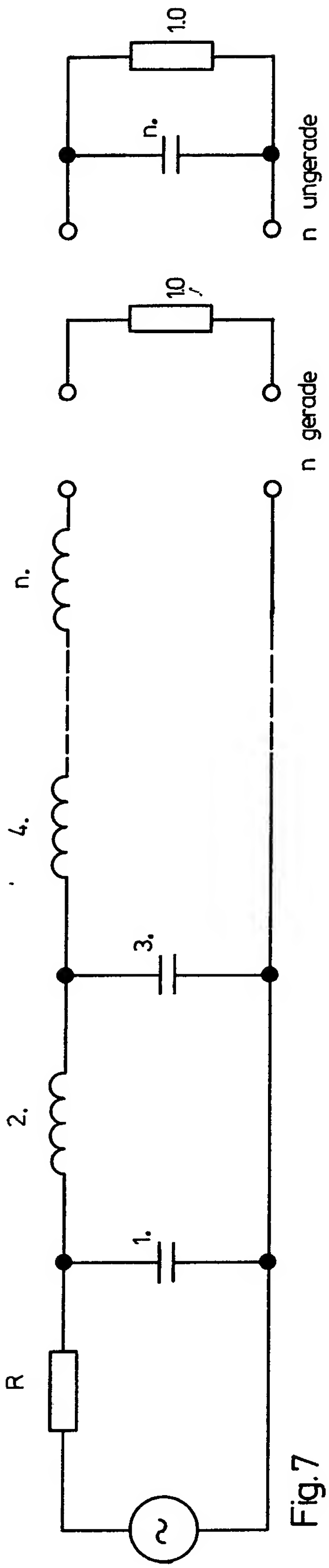

Fig.7

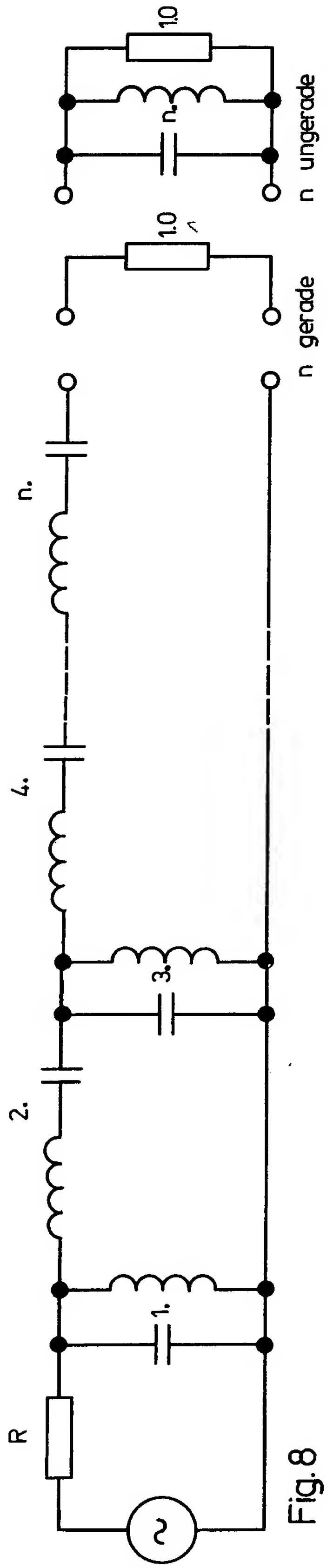

Fig.8

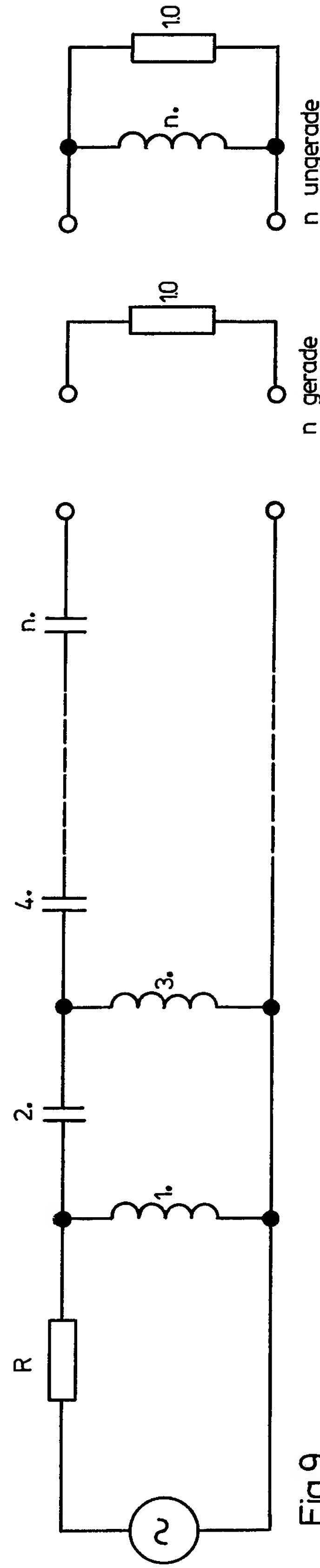

Fig.9

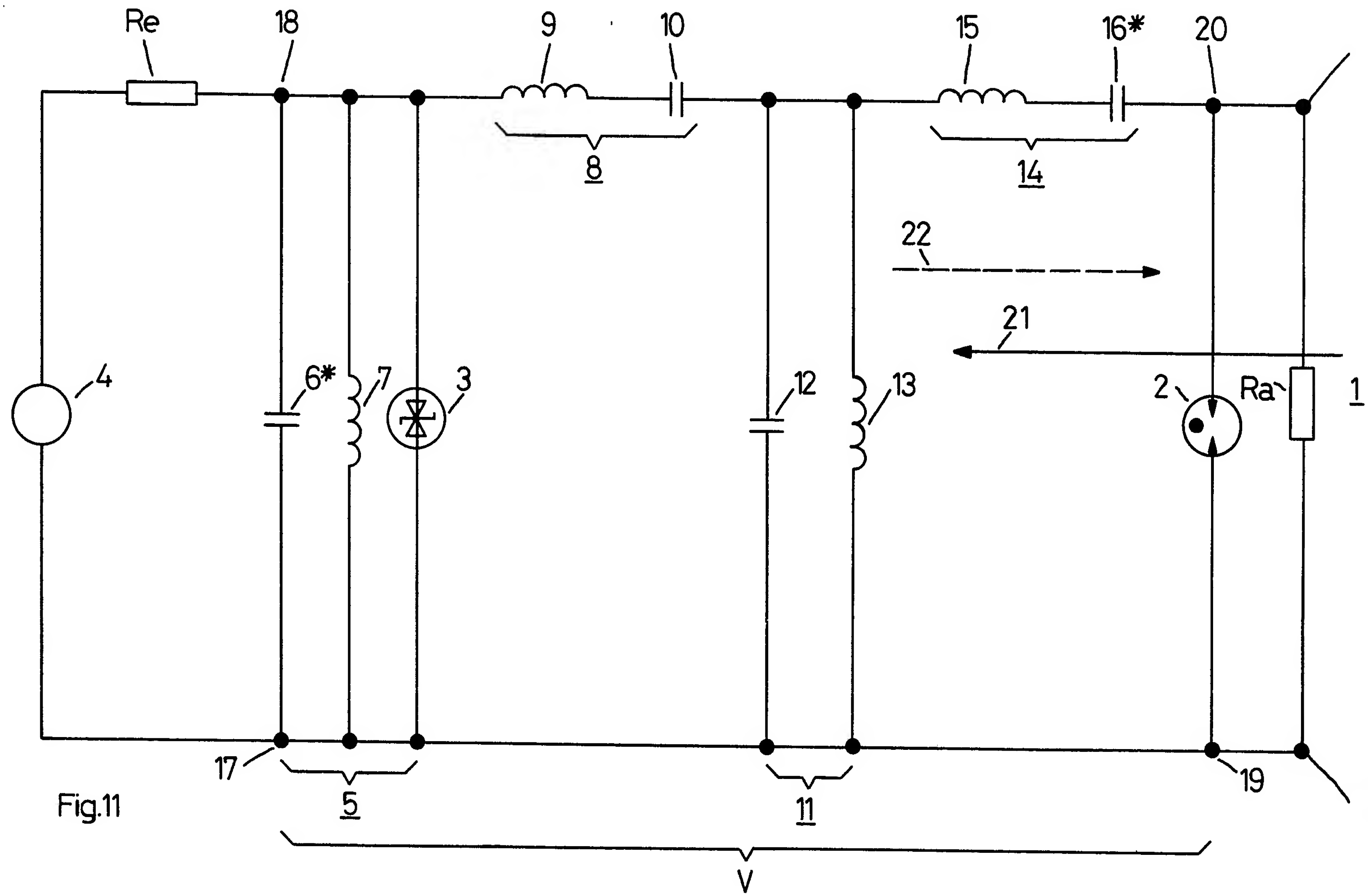

Fig.11

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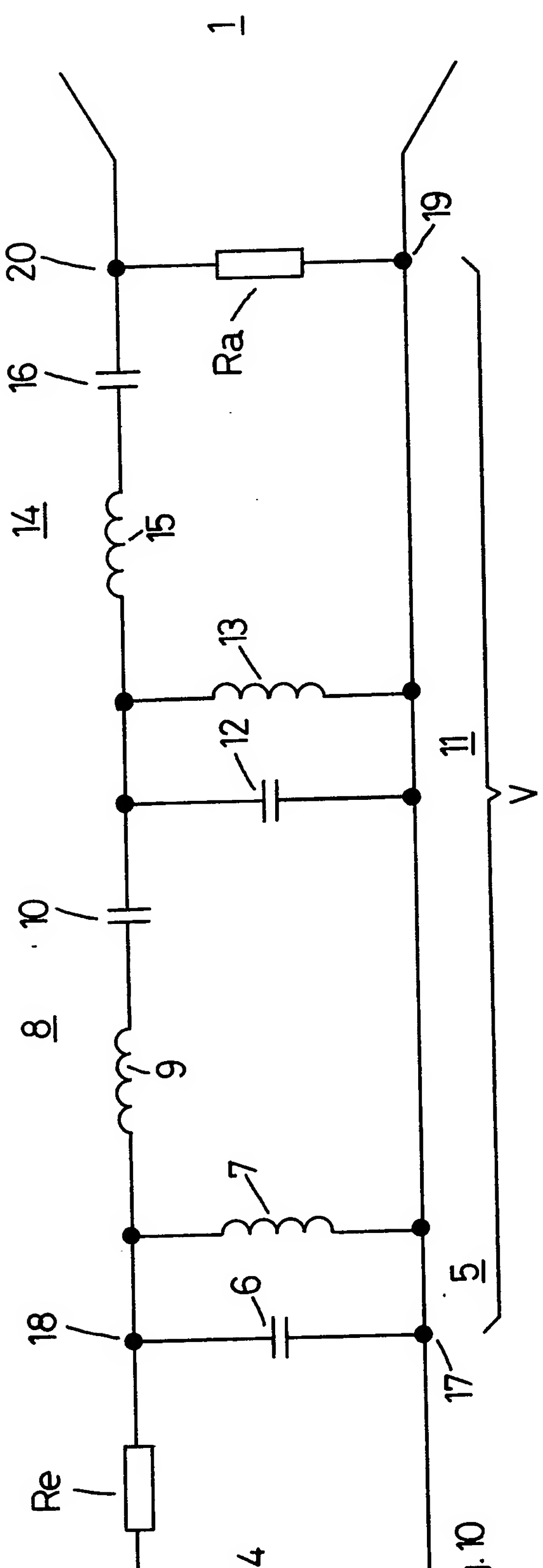

Fig.10

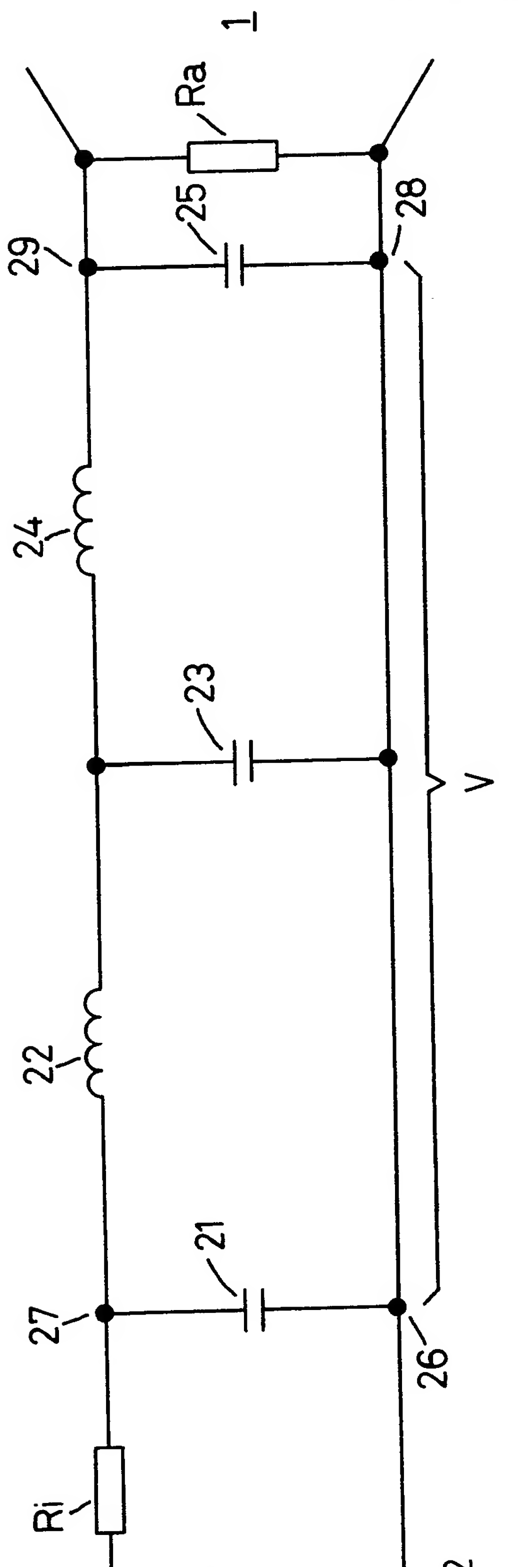

Fig.12

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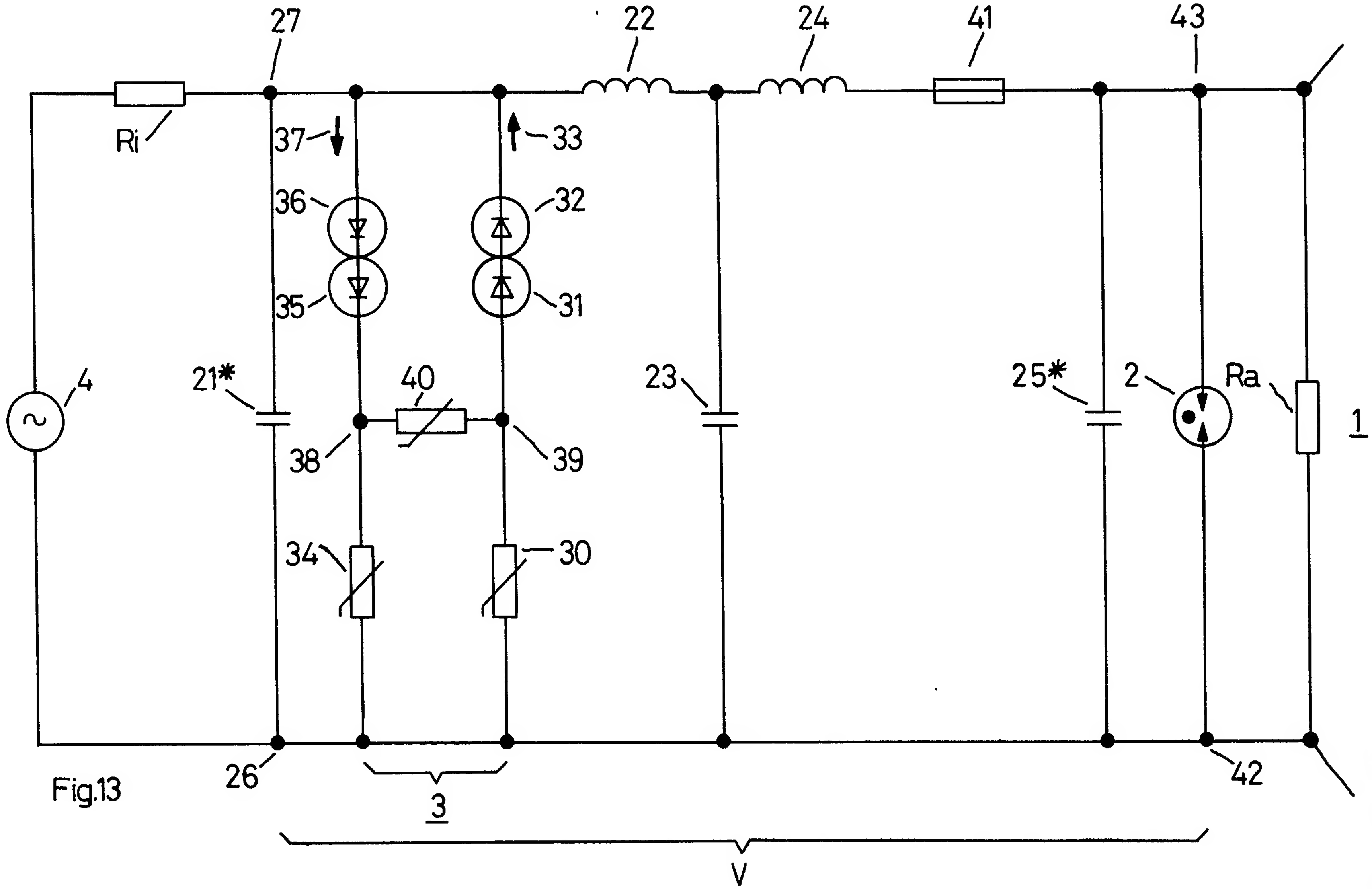

Fig.13

SPECIFICATION

A method of, and an apparatus for, the protection of an electronic device against destruction by strong electromagnetic pulses

This invention relates to the protection of electronic devices against destruction by strong electromagnetic pulses, in particular pulses of nuclear origin.

The following publications are specified as the relevant prior art:

1. EMP Radiation and Protective Techniques, L.W. Ricketts, J.E. Bridges, J. Miletta John Wiley and Sons, New York 1976 ISBN 0-471-01 403-6, in particular Figure 4.51 P. 205
2. U.S. Patent No. 4,021,759
3. German Auslegeschrift No. 2,550,915
4. German Offenlegungsschrift No. 2,753,171 and
5. EMP Electronic Design Handbook, Boeing, Seattle Washington.

Protective apparatus comprising a coarse protection means, such as a spark gap or discharge tubes and a fine protection means connected downstream via a fuse and/or an impedance, such as semiconductor elements and/or varistors are known. It is also known to position a delay member between the coarse protection means and the fine protection means.

According to the present invention, there is provided a method for the protection of an electronic device against destruction by stong electromagnetic pulses while using overvoltage protection elements, wherein the pulse energy which arrives and is distributed over a wide frequency range is divided in terms of frequency and parts of energy which lie in terms of frequency in the working range of the device to be protected or lie in a determined partial range thereof are delayed in time and, parts of energy outside these frequency ranges are reflected.

The invention also provides an apparatus for carrying out this method in which a line leading from outside to a device to be protected is connected to at least one coarse protection means and is guided to at least one fine protection means via at least one frequency-selective delay member, which fine protection means is connected to terminals of the electronic device to be protected.

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 illustrates a typical time curve of the field intensity of a nuclear electromagnetic pulse;
Figure 2 illustrates the curve of the field intensity as a function of the frequency;
Figure 3 is a block diagram illustrating one embodiment;
Figure 4 illustrates an example of a time voltage curve at the output of a coarse protection means;
Figure 5 illustrates an example of a time curve of an interference pulse at the output of a frequency-selective delay member;
Figure 6 illustrates an interference pulse according to Figure 5 which is restricted by a fine protection means;
Figure 7 illustrates a low-pass filter;
Figure 8 illustrates a band-pass filter;
Figure 9 illustrates a high-pass filter;
Figure 10 illustrates a filter for a first embodiment of the invention;
Figure 11 illustrates the first embodiment;
Figure 12 illustrates a structure of a filter for a second embodiment; and
Figure 13 illustrates the second embodiment.

Strong electromagnetic pulses, in particular those which occur in space due to nuclear explosions may destroy electronic devices even at a considerable distance from the centre of the explosion, for example, even at hundreds of kilometers. Since these effects have become known, a number of measures have been proposed to avert such detrimental influences. These problems are treated in great detail in the quoted book "EMP Radiation and Protective Techniques", a Wiley-Interscience Publication, John Wiley and Sons, New York, 1976.

Even if extensive protection is already possible for many devices, for example, by means of appropriate metallic shielding, a problem which has not been satisfactorily solved hitherto exists for certain types of electronic devices, in particular for communications equipment such as transmitters and receivers. Transmitters and receivers, for example for the short-wave range, are connected in terms of operation to an aerial or to an aerial array, for example, for a transmission line. It is evident that pulse energy received by the aerial or the transmission line is directly guided from outside into the relevant device via this aerial, or aerial array or transmission line positioned outside, however effectively the device may itself be shielded. At least some of the pulse energy lies in terms of frequency in the working range of the relevant transmitter or receiver and it reaches the circuit elements thereof via the conventional input filters of the receiver, or output filters of the transmitter which are permeable in the working range.

Since the time of a possible nuclear explosion cannot be forseen, such devices cannot be protected by a precautionary disconnection from the aerial. Instead, they usually have to be continuously ready for use. During the course of a nuclear explosion, operational readiness is indeed not required, because the signal transmission conditions during this time are disturbed anyway. However, immediately after the nuclear

explosion has subsided, the relevant devices should have their normal functional efficiency and readiness.

For this reason, the present invention has an object of fulfilling this requirement.

In the case of both receivers and transmitters, the useful signal levels are smaller by many orders of magnitude than the possibly occurring levels of the nuclear interference pulses mentioned. For example, receivers are dimensioned for receiving signals in the order of magnitude of about one volt and below and military short-wave transmitters are designed, for example, for a power of up to a few kilowatts, so that voltage levels up to about 100 volts result at conventional aerial impedances.

In contrast thereto, in the case of nuclear electromagnetic pulses, there occur field intensities of the order of 100 kilovolts per metre and induced currents of 250 amperes per metre. Thus, the noise levels which are to be expected as a result of this are higher by many orders of magnitude than the useful or signal level mentioned, for which these devices are usually dimensioned.

Furthermore, a characteristic of the nuclear electromagnetic pulses is their extremely high edge steepness. Thus, for example, the maximum value of such a pulse is attained in a rise time of from about 10 to 50 nanoseconds. The decay time of the pulse is of the order of about 1 microsecond.

The frequency spectrum of a nuclear electromagnetic pulse extends over a range of below one MHz to above 100 MHz, and the greatest part of the energy occurs in a range of from about 100 KHz to 100 MHz.

If, for example, a military short-wave transmitter or a short-wave receiver is now considered as an electronic device to be protected, then this device must be designed, for example, for a frequency range of from 10 MHz to 15 MHz.

Thus, it is recognised that the working range of this device lies in the centre of the spectrum of the nuclear electromagnetic pulse, so that in spite of possible adequate shielding measures in the housing of the device, the electromagnetic pulse energy may penetrate into the device in a practically unhindered manner via the terminals of the transmitting aerial, or of the receiving aerial, because the pass-range of the receiving filters on the input side, or of the transmitting filters on the output side is in the spectral range of the electromagnetic pulse. Thus, the entry of destructive interference energy has to be reckoned with, at least within the working range of the device to be protected, in the assumed case of from 10 to 15 MHz.

The present invention proposes to combine at least two different defence measures effectively to restrict the supply of possibly destructive pulse energy to the device to be protected. As the first measure, the interference pulse energy which is received altogether by the aerial, the aerial array or, transmission line is divided in terms of frequency into different parts and care is taken that only that part of interference pulse energy of the broad-band interference pulse which is in the actual working range of the device to be protected, or which is even only in a partial range of this working range is supplied to the device to be protected, whereas parts of interference energy which are outside the mentioned range or partial ranges are reflected and secondly, to ensure optimum ignition order or response sequence of the coarse overvoltage protection and of the fine overvoltage protection by a delay in time of the part of pulse energy supplied to the device.

Thus, an apparatus to implement this method comprises at least one coarse overvoltage protection means and at least one fine overvoltage protection means, and the arrangement is such that the aerial, the aerial array or transmission line conducting the interference pulse energy is initially guided to at least one coarse protection means, and then via at least one frequency-selective delay member to at least one fine overvoltage protection means and from there to the terminals of the device to be protected, i.e. to the input of a receiver, or to the output of a transmitter.

Figure 1 illustrates a typical time curve of the field intensity of a nuclear electromagnetic pulse. The field intensity attains its maximum in a very short rise time of from 10 to 50 nanoseconds. The nuclear electromagnetic pulse decays again within about 1 microsecond.

Figure 2 illustrates the curve of the field intensity F of a nuclear electromagnetic pulse as a function of the frequency. The main amount of energy lies approximately in a range of from 0.1 to 100 MHz. In Figure 2, the transmission characteristic D of a frequency-selective delay member V (not illustrated in Figure 2) is shown with a dash-dotted line. In this case, the delay member V advantageously has a transmission characteristic D which is adapted to the working range B of the device to be protected, or to a partial range thereof. The complete range is divided by the transmission characteristic D of this delay member V into a lower range A and an upper range C, between which lies the working range B of the device to be protected.

Due to the arrangement of the frequency-selective delay member V, the parts of interference pulse energy lying in the lower frequency range A and the parts lying in the upper frequency range C are now reflected, so that they are held off from the device to be protected and only a comparatively small part, namely the part which lies in the frequency range B is allowed through.

If the working range B of a device to be protected lies at the lower end of the interference spectrum, the delay member may be a low-pass filter. However, if the working range lies at the upper end of the frequency range of the interference spectrum, a high-pass filter may be used as the delay member.

However, the frequency-selective delay member will usually be a band-pass filter. In this arrangement, the lower frequency limit of a band-pass filter of this type is preferably selected having a tolerance factor of 1.5, so that the lower frequency limit

$$f_u = \frac{f_{min}}{1.5}.$$

The upper frequency limit f_0 is selected to equal 1.5 × f_{max}, and f_{min} and f_{max} are the limiting frequencies of the working range B of the device to be protected, or of a partial range of this working range.

It is also advantageous to design a harmonic filter which is necessary in anycase in a transmitter, for example, as a frequency-selective delay member V, combined with a coarse overvoltage protection and a fine overvoltage protection. A more comprehensive restriction of the interference pulse energy delivered to the device to be protected may be achieved by subdividing the working range B of the device to be protected into partial regions B_1, B_2 etc., and likewise designing the delay member for these individual partial regions, for example, so that it may be switched over.

Figure 3 is a block diagram of one embodiment. An aerial 1 is connected to a coarse protection means 2, for example, to a spark gap or to a gas-discharge tube. Following on from this course protection means 2 is a frequency-selective delay member V, for example, a band-pass filter which is designed for the working range of the device 4 to be protected. A fine protection means 3, for example, a semiconductor element or a varistor follows on from this frequency-selective delay member V. The complete protection apparatus is denoted with reference number 5. The electronic device 4 to be protected, for example, the input of a short-wave receiver or the output of a short-wave transmitter follows on from the fine protection means 3.

Coarse protection means of the type specified are indeed capable of processing relatively high energy, but they usually only respond with a delay of about 10 nanoseconds. As a result of the very high edge steepness of the nuclear electromagnetic pulses, see Fugure 1, the interference pulse has already attained a very high value U_1 during the response time, so that a relatively high pointed pulse I_1 is substantially produced after the response time T_a. After the coarse protection means 2 has responded, the voltage at this means collapses into a residual or conducting voltage U_2 which lasts from the response time t_1 to the decay time t_2. Figure 4 illustrates an example of a voltage curve at the output of a coarse protection means 2.

Fine protection means, such as, for example, semiconductor elements and varistors and similar protection elements have an advantage over the coarse protection means mentioned in that they are immediately operative, i.e., without a time delay. However, they are usually unsuitable for processing very high energy, but they are capable of restricting interference pulses to a substantially lower level than is usually the case with coarse protection means. Thus, they can protect sensitive electronic devices more effectively than coarse protection means on their own. It is thus appropriate and conventional to use a cascade connection of at least one coarse protection means and at least one fine protection means. A resistor or, for example, an inductor may be provided between both protection means.

If a fine protection means was now directly connected in parallel to the coarse protection means or connected thereto via a resistor, the punctual response of the coarse protection means would be prevented by the more rapid, or delay-free operation of the fine protection means, so that all of the interference energy would be supplied to the fine protection means which is not suitable therefor. For this reason, it is advantageous to connect a delay member V between the coarse protection means 2 and the fine protection means 3, in order to ensure an optimum time procedure of the ignition or of the response of both protection means.

This measure is known, for example, from the quoted book "EMP Radiation and Protective Techniques", Chapter 4.5 and Figure 4.51. A piece of cable is proposed in this book as the delay member V.

Although this solution already provides an improvement with respect to former solutions, it has the considerable disadvantage that all of the interference energy which has been received up until then by the aerial is supplied to the fine protection means, up until the response of the coarse protection means 2, which is very disadvantageous for both the fine protection means 3 itself as well as for the device 4 which is connected thereto. Moreover, the solution of the delay comprising a cable is very voluminous, because a few metres of high-tension-resistant cable are required.

Thus, it is proposed to design the delay member V to be frequently-selective, for example, as a band-pass filter. As a result of this measure, only the part of the interference energy lying in the working range B passes to the fine protection means 3 according to Figure 2, whereas the parts lying in the ranges A and C are reflected, i.e., sent off, that is they are reflected by the aerial.

The coarse protection means 2 and the delay member V thus together produce a weakened and delayed interference pulse I_2. As a result of this, not only is the fine protection means considerably relieved, but a far greater reliability is also provided that only a quantity of interference energy which may actually be overcome by the fine protection means 3 is delivered to this means.

Further advantages may be obtained in that the self-capacitance of the coarse protection means 2 and of the fine protection means 3 is at least partly also included in the capacitors which are required for the production of the frequency-selective delay member V, i.e. of the band-pass filter. It has also proved to be advantageous to connect diodes upstream of such protection elements. Fine protection means in particular, generally, that is mostly have relatively high self-capacitances which substantially only make them suitable, taken separately, for low-frequency ranges, for example, for audio frequency ranges. This disadvantage for the present purpose of use may be overcome by connecting upstream suitable low-capacitance diodes.

Figure 5 illustrates the time curve of an interference pulse at the output of the frequency-selective delay member V. It may be seen that the pulse I_2 which appears at the output of the delay member V is delayed by the delay time $\Delta t = t_3 - t_1$ of the delay member V compared to the pulse I_1 according to Figure 4 and, moreover, it is substantially less pointed due to the frequency-selectivity of the delay member V.

This pulse I_2 which is delayed in time and is substantially more moderate according to Figure 5 is further

restricted in its amplitude by the fine protection means 3 connected downstream of the frequency-selective delay member V, so that a substantially lower-energy interference pulse I_3 which is harmless to the device 4 to be protected appears according to Figure 6 at the output of the fine protection means 3, or at the output of the complete protection device 5 according to Figure 3. Thus, the complete interference protection device 5 produces an interference pulse I_3 which is greatly restricted and is delayed in time and is also harmless to very sensitive devices 4 to be protected, such as, for example, a short-wave receiver or a short-wave transmitter and in particular, to the semiconductor elements thereof.

In addition to the very effective reduction in the energy supplied to the devices to be protected in their working range, additional advantages of an apparatus 5 of this type are also provided. In the case of a transmitter, it is namely conventional to position a harmonic filter which is known *per se* between the transmitter and the aerial in order to avoid radiation of detrimental harmonic waves of the transmitter. As a result of suitably dimensioning the delay member V according to the present invention, it may also take over the function of the harmonic filter, so that, all in all, there is hardly a multiple expense. However, also in the case of a receiver as a device to be protected, the use of the frequency-selective delay member is also advantageous, because, for example, the image frequency suppression and/or the suppression of transmitters operating on the intermediate frequency is also improved by the additionally pre-connected selection means. Even the signal/noise ratio is improved.

Furthermore, it should be considered that, for example, in the case of a transmitter, signal distortions, i.e. harmonic waves may arise through the output signal of the transmitter at the fine protection means which has a non-linear characteristic, for example, varistors or diodes. If, as known from the prior art, only a piece of cable is provided as the delay member V, these harmonic waves would finally also arrive at the aerial via the delay cable and would be radiated thereby. However, this is not desired with respect to the very severe official requirements for harmonic wave freedom of transmitter signals.

Thus, a further advantage of the present invention is that not only harmonic waves which are possibly originally present in the transmitter output signal, but precisely also those harmonic waves which only undesirably occur due to the fine protection means are effectively prevented from arriving at the aerial by the frequency-selective delay member V.

If the protection apparatus 5 (Figure 3) is positioned in a transmitter, then, with transmitting levels which are adequate for this purpose, after a response, initiated by an external interference pulse of the coarse protection means, for example a gas-filled photocell, it could happen that this cell "continues to burn", i.e. is not extinguished after the decay of the interference pulse, because the energy required for maintaining the conducting voltage (see Figures 4, U_2) is now supplied by the transmitter. A situation of this type is undesirable. However, it may simply be overcome by inserting a fuse, for example, a safety fuse in the longitudinal branch of the delay member. It is also possible to use an overload connection which automatically responds to the interference.

According to the present invention, the necessary frequency-selective delay member V is produced as a filter. The structure and dimensioning of such a filter is also determined by the position of the working range B of the device 4 to be protected (see Figure 3) with respect to the curve of the field intensity F of the interference pulse as a function of the frequency (see Figure 2).

If the working range B of the device 4 to be protected lies in terms of frequency at the lower end of the spectrum, or of the range A, then a low-pass filter may preferably be provided as the filter, approximately having the structure according to Figure 7. However, if the working range B lies in the centre frequency range, as according to Figure 3, then a band-pass filter is preferably selected, approximately having a structure according to Figure 8. Finally, if the working range B lies in terms of frequency at the upper end of the range C, see Figure 2, i.e. towards about 100 MHz, then a high-pass filter is preferably selected, approximately having a structure according to Figure 9. *n* denotes the number of the members of a filter. 1.0 denotes the standardised load.

Filters of the type specified are known from the prior art. They may be dimensioned depending on the required structure and band width and attenuation, based on known Tables and transformation formulae. In this respect, reference is made to the following publications:

6. "Handbook of Filter Synthesis,
   Anatol I. Zverev
   John Wiley and Sons, Inc. New York 1967
   Library of Congress Catalog Card Number 67-17 352"

and

7. "Tabellenbuch Tiefpässe,
   Gerhard Pfitzmaier
   Siemens AG Berlin-München, 1971"

Two concrete embodiments will now be described in the following.

First embodiment

Filter structure according to Figure 10, band-pass filter. Values according to literature "6.", in particular page 312. The device 4 to be protected is a short-wave receiver having an input resistance R_e of 50 Ohm and a frequency range (working range) of from 1.2 MHz to 12 MHz. The filter has four members, namely:

First member 5 :	first parallel-resonant circuit having capacitor 6 and inductor 7;
second member 8:	first series resonant circuit having inductor 9 and capacitor 10;
third member 11:	second parallel-resonant circuit having capacitor 12 and inductor 13; and
fourth member 14:	second series resonant circuit having inductor 15 and capacitor 16.

The device 4 to be protected is connected with its input terminals to the input terminals 17 and 18 of the filter. The aerial, aerial array or transmission line 1 is connected to the output terminals 19 and 20, as a result of which, the filter acting as a frequency-selective delay member V is charged on the output side with the terminating resistance R_a provided.

The delay member V constructed as a band-pass filter is thus not only used as a frequency-selective delay member, but it also ensures a correct electrical adaptation both on the side of the device 4 to be protected as well as on the side of the aerial. It should now be considered that a filter structure according to Figure 10 affords the possibility of using the capacitance-loaded coarse and fine protection means 2 and 3 (see Figure 3), without the self-capacitances thereof having a detrimental influence on the high-frequency characteristics of the protection device 5 (see Figure 3).

The following values are produced for the first embodiment described with reference to Figure 10 for the assumed working range of from 1.2 MHz to 12 MHz:

Capacitor	6	173 pF	1st member
Inductor	7	9.77 μH	
Inductor	9	1.05 μH	2nd member
Capacitor	10	1.61 nF	
Capacitor	12	417 pF	3rd member
Inductor	13	4.05 μH	
Inductor	15	435 nH	4th member
Capacitor	15	3.89 nF	

Figure 11 illustrates a practical realisation of the filter structure according to Figure 10. It may be seen that the capacitor of the coarse protection means 2 and of the fine protection means 3 is integrated into the filter structure. This integration of the capacitor of the protection means is to be considered in the practical choice of the capacitors 6* and 16*.

In this embodiment according to Figure 11, a gas-filled photocell of the "UC 90" type, manufactured by Cerberus AG, Männedorf, Switzerland is provided as the coarse protection means 2.

A "Surge Suppressor" of type GHV 16, produced by General Semiconductor Ind. Inc. Arizona, U.S.A. is provided as the fine protection means 3 in the embodiment according to Figure 11.

The frequency-selective delay member V not only reduces the interference energy supplied to the fine protection means 3, but reflects some of this interference energy penetrating in the direction of arrow 21 into the direction of arrow 22 and this energy thereby increases the interference voltage which is at the coarse protection means 2. As a result of this, this coarse protection means 2, for example a gas-filled photocell responds more rapidly than before at time t_1, (see Figure 4). These effects may not be obtained by the piece of cable known from the prior art as a delay member. Moreover, a piece of cable as a delay member does not allow a sufficiently optimal adaptation over a broad frequency range.

Second embodiment

Filter structure according to Figure 12, low-pass filter. Values according to literature "7", page 427. The device 4 to be protected is a short-wave transmitter having an internal resistance R_i of 50 Ohm and a frequency range of from 1 to 27 MHz.

The filter has five elements, namely:

First element	:	Capacitor 21
Second element	:	Inductor 22
Third element	:	Capacitor 23
Fourth element	:	Inductor 24
Fifth element	:	Capacitor 25

The device 4 to be protected, i.e. the short-wave transmitter is connected with its output terminals to the

input terminals 26 and 27. The aerial, aerial array or transmission line 1 is connected to the output terminals 28 and 29 of the filter. As a result of this, the filter acting as a frequency-selective delay member V is charged on its output side with the terminating resistance R_a provided. The delay member V which is constructed as a low-pass filter is thus not only used as a frequency-selective delay member, but it also ensures a correct electrical adaptation both on the side of the device 4 to be protected as well as on the side of the aerial, and this is over a wide frequency range. It should be considered that a filter structure according to Figure 12 also affords the possibility of using the capacitance-loaded coarse and fine protection means 2 and 3 (see Figure 3), without the self-capacitances thereof having a detrimental influence on the high-frequency characteristics of the protection device 5 (see Figure 3).

The following values are produced for the second embodiment which is described with reference to Figure 10 for the assumed working range of from 1 to 27 MHz:

Capacitor	21	52 pF
Inductor	22	278 nH
Capacitor	23	130 pF
Inductor	24	278 nH
Capacitor	25	52 pF

A filter of this type has a negligible power loss, for example, the attenuation amounts to less than 0.0004 dp and the standing wave ratio is completely adequate for the intended purpose.

Figure 13 illustrates a practical realisation of the filter structure according to Figure 12. It may be seen that the capacitor of the coarse protection means 2 and of the fine protection means 3 is integrated into the filter structure. This integration of the capacitor of the protection means is to be considered in the practical choice of the capacitors 21* and 25*.

A gas-filled photocell of the UC 470 type, produced by Cerberus AG, Switzerland is provided as the coarse protection means 2 in this embodiment according to Figure 13. A connection arrangement of two metal oxide varistors of the ERZ-C14 DK 391 type, produced by Matsuhita Electric, Japan, each having two diodes of the UES 1306 type, produced by Unitrode Corp. Lexington MA, USA connected thereto in series is provided as the fine protection means 3 in the same embodiment. In this arrangement, the two diodes 31 and 32 associated with one metal oxide varistor 30 are connected in permeable manner in one transmission direction 33 and on the other hand, the two diodes 35 and 36 which are associated with the other metal oxide varistor 34 are connected in permeable manner in the other direction, i.e. in the opposite direction 37.

Another metal oxide varistor 40, for example, of the ERZ-C14 DK 751 type, produced by the firm of Matsuhita, previously mentioned, is connected between the connection points 38 and 39 of the metal oxide varistors 30 and 34 mentioned each with the diode 31 or 35, to protect the diodes 31, 32 and 35, 36 against voltage break-through in the case of a possible inverse interference pulse. A capacitor 130 pF of the MHG type, produced by Micro-Electronics Ltd. Israel is provided, for example, as the capacitor 23. The inductances 22 and 24 each have a value of 278 nH.

In the Example according to Figure 13, the device 4 to be protected, i.e. the short-wave transmitter mentioned has an internal resistance R_1 of 50 Ohm and the aerial or aerial array or transmission line 1 represents a load resistance R_a also of 50 Ohm.

In order to protect the short-wave transmitter 4 against a possible overload, in case the coarse protection means 2, i.e. the gas-filled photocell is ignited by an interference pulse and thereafter the conducting voltage U_2, see Figure 4, is maintained by the transmitting signal of the transmitter after decay of the interference pulse during the time t_2 (see Figure 4), a safety fuse 41 is connected in a longitudinal branch of the filter, for example, in series to inductor 24. In case the gas-filled photocell 2 should continue to burn in the manner mentioned, a short circuit could practically be produced as a result of this between the connection points 42 and 43. A strong current would then flow from the device 4, i.e. from the short-wave transmitter via the inductors 22 and 24 which this safety fuse, for example, 6.3 A of the FF 220 V type, produced by Wickmann, BRD would fuse.

Instead of using a safety fuse 41, an automatic overload fuse which is known *per se* with a delayed re-connection device may also be provided.

In certain cases of use of the present invention, an apparatus is used, for example, in which a short-wave transmitter 4 is connected to an automatic aerial adaptation device which is positioned near the transmitting aerial which is set up at a distance, via a comparatively long coaxial cable, for example, a cable 50 m long as a transmission line. In this arrangement, not only is the high-frequency transmitting energy transferred via this coaxial cable, but, for example, so is direct current energy to operate the aerial adaptation device. In this case, the relevant direct current source of the aerial adaptation device is also protected against overload by the safety fuse 41 mentioned, during the occurrence of an interference pulse.

CLAIMS

1. A method for the protection of an electronic device against destruction by strong electromagnetic pulses while using overvoltage protection elements, wherein the pulse energy which arrives and is

distributed over a wide frequency range is divided in terms of frequency and parts of energy which lie in terms of frequency in the working range of the device to be protected or lie in a determined partial range thereof are delayed in time and parts of energy outside these frequency ranges are reflected.

2. An apparatus for carrying out the method according to Claim 1, wherein a line leading from outside to a device to be protected is connected to at least one coarse protection means and is guided to at least one fine protection means via at least one frequency-selective delay member, which fine protection means is connected to terminals of the electronic device to be protected.

3. An apparatus according to Claim 2, wherein the terminals are the input terminals of a receiving device.

4. An apparatus according to Claim 2, wherein the terminals are the output terminals of a transmission device.

5. An apparatus according to Claim 4, wherein the delay member is a harmonic filter of the transmission device.

6. An apparatus according to any one of Claims 2 to 5, wherein the delay member (V) is a band-pass filter or a low-pass filter or a high-pass filter, and the coarse and/or fine protection means have capacitors which are included in the filter structure.

7. An apparatus according to Claim 6, wherein at least one diode is connected in series to at least one coarse and/or fine protection means.

8. An apparatus according to any one of Claims 2 to 7, wherein the frequency-selective delay member may be switched over to partial ranges of the working range of the device to be protected.

9. An apparatus for the protection of an electronic device against destruction by strong electromagnetic pulses substantially as described with reference to the accompanying drawings.

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